Bulletin of the Museum of Comparative Zoölogy,
AT HARVARD COLLEGE.
VOL. XIII. No. 9.

THE SUPERIOR INCISORS AND CANINE TEETH OF SHEEP.

BY FLORENCE MAYO.

WITH TWO PLATES.

CAMBRIDGE:
PRINTED FOR THE MUSEUM.
JUNE, 1888.

Prof. Hermann Fol
With the compliments of
E. L. Mark

No. 9. — *The Superior Incisors and Canine Teeth of Sheep.* By FLORENCE MAYO.*

IN 1839 Goodsir (p. 83) stated that "the cow and sheep, and probably all the other ruminants, possess the germs of canines and superior incisives at an early period of their embryonic existence."

This statement remained undisputed until 1873, when Pietkewickz (p. 509) denied the existence not only of the teeth germs, but also of the so-called dental lamina. He says: "Dans une longue série de preparations faites sur des embryons de boeuf et de mouton, pris depuis le moment le plus reculé de la vie embryonnaire jusqu'à une longuer de 30 centimetres, non seulement je n'ai jamais constaté la présence de follicules, mais je n'ai même jamais trouvé trace de la lame épitheliale."

Legros and Magitot ('73, p. 452) content themselves with simply quoting the results attained by Pietkewickz, but add nothing of their own.

Somewhat later, Piana ('78, p. 222) asserts that the epithelial lamina of the upper jaw extends to the region where the lateral incisors ought to develop, and that the enamel germs of the canine teeth exist at a certain stage of development, but soon abort.

Pouchet and Chabry ('84, p. 158), calling the canine tooth the fourth incisor, admit the existence of a dental lamina in the region of the upper jaw, which is directly over the second incisor of the lower jaw, but claim that in front of this point it becomes gradually merged into the crest of the plunging wall. They add: "Ainsi non seulement la région incisive des ruminants ne présente aucun vestige de dents, contrairement à ce qu'on avait cru à une certaine epoque, mais elle ne possède pas même de lame dentaire differentiée, dans toute son étendue."

In view of these conflicting statements and the theoretical interest of the questions involved, further studies upon the subject are desirable. Therefore, at the suggestion of Prof. E. L. Mark, and under his direction, I have undertaken to re-examine the development of the teeth in sheep embryos of different ages, hoping to be able to add something to what was already known. My observations are as follows: —

* Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College, under the Direction of E. L. Mark. — No. XIII.

The jaws of a sheep embryo whose length was 37 m.m. were sectioned so that the plane of the first section was parallel to the median plane of the jaw. After a small number of sections had been cut parallel to this plane, the object was slightly rotated, so as to keep the plane of the sections nearly perpendicular to the outer margin of the jaw. By thus frequently changing the plane of cutting, each section of the series was a true cross-section of the part of the jaw from which it was taken. This method of cutting must give more satisfactory results than can be had by cutting either parallel or perpendicular to the median plane of the jaw without any change in direction.

In the first of the sections of the upper jaw, in the region which corresponds to the first incisor of the lower jaw (fig. 1), the dental lamina is not distinct from that portion of the buccal epithelium which Pouchet and Chabry ('84, p. 152) have called the "mur plongeant." But before the first incisor of the lower jaw has been passed, and in the region of the second and third incisors (figs. 2, 3, and 5), the dental lamina, although not sharply marked off from the "plunging wall," is readily distinguishable from it. By comparing figs. 1 and 3, one finds that the epithelial tissue in fig. 3 sinks deeper into the mesoderm than in fig. 1; that the deep portion forms an angle of about 45° with the axis of the plunging wall in fig. 1; and that the width of this deep portion, that is, the distance from the base of the malpighian layer on one side, to the base of the same layer on the other side, is less than the width of the plunging wall in fig. 1. In fig. 3 the dotted line is introduced to show where the boundary of the plunging wall, as it appears in fig. 1, would fall if it were "projected" on to the plane of this section. This deep portion beyond the dotted line, although continuous with the plunging wall, and not histologically different from it, I believe to be, both by reason of its size and its direction, the most anterior indication of the dental lamina. In the sections through the canine region of the same jaw (fig. 7) the conditions of the dental lamina and plunging wall are the same as in the incisor region.

Dursy ('69) gives drawings of several sections through the incisor and canine regions of a sheep embryo at about the same stage as the one just described. He says (l. c., p. 214): "Taf. III. Fig. 1–8 zeigt die Zahnfurche mit dem Schmelzkeim von einem Schafsfötus, dessen Gaumen im Schliessungsprocess begriffen war; auffallend daran ist die Weite der Furche und daher auch die Breite der hellen Kernmasse des Schmelzkeims an *allen* Schnitten, die somit an den zahnlosen Stellen beim Schafe um diese späte zeit noch vorhanden ist." Dursy evidently

disregards the existence of the dental lamina and calls it the enamel germ, of which at this stage I find no trace. He also figures (Taf. III. Fig. 1–9), as existing throughout the incisor and canine regions, an area — or, as Tomes calls it, a "halo" — in the mesoderm which in his opinion always precedes the development of the dentine germ, and is probably caused by a concentration of mesodermic nuclei. I have been unable to find, in any of the stages of development, this halo existing in any region of the upper jaw farther forward than that of the first premolar. The only indication of such a condition has been a slightly increased concentration in the nuclei immediately surrounding the epithelial germ, which, however, is hardly more pronounced than in the mesoderm which abuts upon neighboring portions of the buccal epithelium, and which is never sharply marked off on the deep side from other concentrations of nuclei which presage the formation of cartilage in the deeper mesoderm.

In an embryo 56 mm. long, cut in the same manner as the one just mentioned, the dental lamina is present *throughout the incisor region.* When studied with a low magnifying power (× 33), the sections through a part of the region of the first incisor, as in the younger stage, show no differentiation of a lamina from the plunging wall (figs. 11–14); but when a higher power is used (× 175), the malpighian layer of that portion of the plunging wall from which the lamina ought to proceed, is found to present an irregular outline on the side toward the mesoderm (fig. 30, *l. lng.*). It is no longer a layer one cell deep, but is composed of irregularly arranged cells, several deep. In the sections further back, behind the middle of the first incisor, and throughout the remaining incisor region (figs. 15–19), the dental lamina can be distinguished from the plunging wall by its size and direction. Its malpighian layer on the lingual side has undergone the same change as that just described in the region of the first incisor. The histological condition of the lamina in this region is identical with that which is presented at an early stage of development by the lamina, in regions where teeth are normally produced.*

* I find that the two walls of the dental lamina in the premolar region of the upper jaw, and in the incisor, canine, and premolar regions of the lower jaw, are histologically different. Pouchet and Chabry have mentioned this fact (pp. 154–155), and have given the names "adamantine" and "abadamantine" to the two walls of the lamina; but they do not state what the structural difference is. I have found that the malpighian layer of the lingual wall of the lamina is several cells deep. These cells are prismatic in form, and are compactly though irregularly

The fact that the dental lamina in the region of the second and third incisors is directly continuous with the differentiated portion of the plunging wall in the region of the first incisor, and has the same histological characteristics as that portion, seems good reason for believing that the latter is the representative of the dental lamina, which in this region never becomes further developed; whereas in the region of the second and third incisors it has become prolonged, and has changed its direction, owing to the multiplication of its undifferentiated cells.

In the canine region (fig. 20), the dental lamina at the place of its connection with the plunging wall has become very narrow. Its width at this point is very little more than the combined width of the two malpighian layers which form its walls, the corneous layer of epithelium being at this stage almost imperceptible. The deeper portion of the lamina by its enlargement has given rise to an enamel germ, which, although much smaller than the corresponding germ on the lower jaw, has the same histological characteristics.

The next stage studied was that of an embryo 87 mm. long. The lamina in the region of the first incisor (fig. 21) seems neither to have advanced nor to have retrograded in development from the condition in the embryo 56 mm. long. In the region of the remaining incisors (figs. 22, 23) the walls of the dental lamina have become thicker, and the corneous layer of epithelium forming its centre has undergone the same change as in the centre of the canine enamel germ of the preceding stage, — the cells are smaller and less regular in shape. In the region of the third incisor (fig. 31) the differentiated portion of the dental lamina, together with some of the unmodified portion, has begun to separate from the buccal epithelium; the mesodermic tissue by its ingrowth occupies for some extent the region which in earlier stages was uninterrupted epithelium. Although in this condition the lamina has a comparatively broad connection with the plunging wall, sections through the posterior portion of the incisor region show it entirely

arranged. On account of this irregularity the layer is in some places broader than in others, and presents an irregular outline on its mesodermic side. The labial wall of the lamina is histologically unchanged from the malpighian layer of the buccal epithelium. It is one cell deep, and has an even outline on the side toward the mesoderm.

The lingual wall increases in extent as the result of cell multiplication and forms the base of the enamel organ. Since the cells of the base of the enamel organ surround the dentine germ and at length produce the enamel, it is obvious that the lingual wall of the lamina produces, first, the enamel organ; and finally, the enamel.

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readily sees that the disappearance of the superior incisors and canines is progressive. In the region of the incisors the evidences even of the beginnings of tooth development have almost disappeared, the region of the first incisor being the least differentiated portion of the tract, while the canine region is represented by a moderately large, but functionless enamel sac. Since in some ruminants destitute of incisors, small rudimentary canine teeth are found on the upper jaw of the adult animal, it is a fair inference that the teeth are being lost from before backward, and that the canine teeth, the last to disappear from the sheep, in those cases undergoing degeneration, although not wholly functionless.

If it is admitted that the history of the development of the individual reproduces, at least in part, the history of the ancestors of that individual, and that the changes in development take place in the same order as in the ancestors, then we have reason for believing that the progenitors of the ruminants possessed incisors and canine teeth on the upper jaw; that these teeth becoming, perhaps by a change in environment, no longer necessary for obtaining food, have gradually ceased to develop; and that the disappearance of the teeth has been a progressive process, beginning with the middle incisors and gradually involving the teeth farther back.

Cambridge, September, 1887.

BIBLIOGRAPHY.

Dursy, Emil.

'69. Zur Entwicklungsgeschichte des Kopfes des Menschen und der höheren Wirbelthiere. Tübingen, 1869. 12 + 232 pp. mit einem Atlas von 9 Taf.

Goodsir, John.

'39. On the Follicular Stage of Dentition in the Ruminants, with some Remarks on that Process in the other Orders of Mammalia. Report of the British Association for the Advancement of Science for 1839. Notices and abstracts of communications, pp. 82–83. London, 1840.

Kölliker, A.

'63. Gewebelelehre. Leipzig, 1863. pp. 406–424.

Legros, Ch., et E. Magitot.

'73. Origine et Formation du Follicule Dentaire chez les Mammifères. Journal de l'Anatomie et de la Physiologie. Tom. IX., 1873, pp. 449–503. Pls. XV.–XX.

Owen, Richard.

'40–'45. Odontography. London, 1840–1845.

Piana, Gio. Pietro.

'78. Osservazioni intorno all' esistenza di rudimenti di denti canini ed incisivi superiori negli embrioni bovini ed ovini. Memorie dell' Accademia delle Scienza dell' Istuto di Bologna. Serie III., Tomo IX., Fasicolo 2, pp. 217–225. 1 Tav.

Pietkewickz, V.

'77. De la valeur de certains arguments de trasformisme, empruntés à l'evolution des follicules dentaires chez les Ruminantes. Comptes rendus. Paris, 1877. Tom. 84, No. 11, pp. 508–509.

Pouchet, G., et L. Chabry.

'84. Contribution a l'Odontologie des Mammifères. Journal de l'Anatomie et de la Physiologie. Tom. XX., 1884, pp. 149–192. Pls. V.–VII.

Tomes, Charles S.

'82. Manual of Dental Anatomy, Human and Comparative. Second edition. London, 1882. 8 + 440 pp.

Waldeyer, W.

'72. Structure and Development of the Teeth. Stricker's Manual of Histology. New York, 1872, pp. 321–341.

EXPLANATION OF FIGURES.

The following abbreviations are used in the figures.

cnn.	Canine.	*lng.*	Tongue.
crt. Mkl.	Meckel's Cartilage.	*l. lng.*	Lingual side.
e t.	Epithelium.	*md.*	Lower jaw (and os mandibularis).
g. de.	Dentine germ.		
g. cnn.	Enamel-organ germ of canine.	*ms d.*	Mesoderm.
g. en a.	Enamel-organ germ.	*mur.*	Plunging wall.
g. i'.	" " of first incisor.	*mx.*	Upper jaw (and os maxillaris).
g. i''.	" " second "	*n.*	Nerve.
g. i'''.	" " third "	*o. en a.*	Enamel organ.
g. pr. mol'.	" " first premolar.	*pr. mol.*	Premolar.
i.	Incisor.	*st. con.*	Stratum corneum.
la. de.	Dental lamina.	*st. Mpg.*	Stratum Malpighi.
l. lab.	Labial side.		

The average thickness of the sections is about 7.5 μ, and the number of each section in the series to which it belongs is indicated by the number in parenthesis adjacent to the number of the figure.

PLATE I.

Figures 1–25 are magnified 17 diameters; figures 26–29a, 11 diameters; figures 30–37, 175 diameters. All were drawn with the aid of the Abbe camera.

Figures 1–10 are from sections of the left side of the jaws of an embryo sheep, 37 mm. long, preserved with picrosulphuric acid, stained by means of Czoker's cochineal followed by alcoholic borax-carmine, imbedded in paraffine and mounted in Canada balsam. The figures all show the anterior face of the sections, which were so cut that the plane of the first section was parallel to the median plane of the head, the object being gradually rotated so as to keep the plane of the sections as nearly as possible perpendicular to the outer margin of the jaw.

Fig. 1 shows the plunging epithelial wall of the upper jaw, and the centre of the germ of the enamel organ of the first incisor on the lower jaw.

Fig. 2. On the lower jaw the section passes through the region between the first and second incisors, where only the dental lamina is to be seen. On the upper jaw the plunging wall is continued into the dental lamina without there

being any well-marked division between the two. They have a slightly different direction.

Fig. 3. A section through the middle of the region of the second incisor of the lower jaw. On the upper jaw the dotted line shows approximately the outline of the plunging wall of Fig. 1, as it would appear when projected on to the plane of this section. The portion beyond the dotted line is the dental lamina.

Fig. 4 is from a section about midway between the second and third incisors of the lower jaw.

Fig. 5 passes through the middle of the third incisor of the lower jaw.

Fig. 6 is from the region between the third incisor and canine tooth.

Fig. 7 shows the enamel germ of the canine tooth on the lower jaw. On the upper jaw the dental lamina can be distinguished from the plunging wall by its size and direction, as in the preceding figures.

Fig. 8. This section passes through the region between the canine tooth and the first premolar on the lower jaw. The dental lamina of the lower jaw no longer appears as an outgrowth from the epithelium of the plunging wall. The dental lamina of the upper jaw is much smaller than in the preceding sections.

Fig. 9 shows the middle of the enamel germ of the first premolar tooth of both jaws. The asterisk marks the position of a longitudinal ridge of epithelium near the base of the dental lamina.

Fig. 10. A section from the region between the first and second premolars. The dental lamina is pear-shaped in section throughout this region. The lateral ridges at the base of the dental laminæ are also continued through the greater part of the region.

Figs. 11–20 are sections through the left side of both jaws of a sheep embryo 56 mm. long, which was treated in the same manner as the embryo of 37 mm., with the exception that it was stained in Grenacher's borax carmine only. The sections were cut in the same manner as in the figures just described.

Figs. 11–15 are sections through the region of the first incisor of the lower jaw, showing the enamel germ of the first incisor as it appears in different regions. On the upper jaw the dental lamina and plunging wall are seen. Fig. 14 is through the centre of the enamel organ of the incisor.

Fig. 16 passes between the first and second incisors on the lower jaw. The dental lamina of the upper jaw has become broader, and its section therefore appears more elongated.

Fig. 17 passes through the middle of the second incisor on the lower jaw.

Fig. 18 shows the dental lamina in the regions between the second and third incisors.

Fig. 19. This section is taken through the centre of the enamel germ of the third incisor of the lower jaw.

Fig. 20 is through the middle of the enamel germ of the canine tooth of both jaws.

Figs. 21–25a are sections of the upper jaw of a sheep embryo 87 mm. long, treated in the same manner as the embryo 37 mm. long. The figures show the anterior faces of the sections through the upper jaw of the right side.

Fig. 21 shows the extent of the plunging wall and the dental lamina in a region opposite the middle of the first incisor of the lower jaw.

Fig. 22. The same in the middle of the second incisor region.

Fig. 23. The same in the middle of the third incisor region.

Fig. 23a shows the appearance seven sections further back than Figure 23.

Fig. 24 is a section behind the centre of the third incisor, showing a part of the dental lamina cut off from the buccal epithelium by the ingrowth of mesoderm.

Fig. 25 is a section through the middle of the canine region behind the region where there is a narrow connection of the enamel-organ germ with the buccal epithelium.

Fig. 25a. The enamel germ is divided by the deepening of a constriction shown in Figure 25 into two arms, the cross-sections of which appear in this figure as two isolated patches of epithelium.

Figs. 26–29a are sections through the left half of the upper jaw of an embryo sheep 112 mm. long, which was hardened in chromic acid and stained with Czoker's cochineal, followed by borax carmine. The sections were made in the same way as described in Figs. 1–10. They are magnified only 11 diameters.

Fig. 26 shows the condition of the plunging wall in the region opposite the first incisor of the lower jaw.

Fig. 26a shows the dental lamina more sharply marked off from the plunging wall as seen a few (18) sections further back than Fig. 26.

Fig. 27 is a section through the middle of the region opposite the second incisor of the lower jaw, showing a small but well defined dental lamina.

Fig. 28 shows the dental lamina in the region of the third incisor.

Figs. 29, 29a, are sections through the canine region.

Fig. 29 shows the rudimentary lamina to be still continuous with the buccal epithelium; but four sections further back it is detached from the "wall."

Fig. 29a. Back of the canine region the lamina is continued as a ridge or fold of epithelium, which soon changes from a horizontal to a vertical position.

PLATE II.

All figures of this plate are magnified 175 diameters.

Fig. 30. The deep portion of the dental lamina of Fig. 14. The change in the thickness of the malpighian layer is to be seen here, also its irregularity of outline.

Fig. 31 is a highly magnified view of the incisor region shown in Fig. 24. The difference between the differentiated and the undifferentiated portions of the lamina, which are here both surrounded by mesoderm, is well marked.

Fig. 32 gives a view of a portion of Fig. 25. The histological condition of the canine germ is the same as that of the differentiated portion of the dental lamina in Fig. 31.

Figs. 33–35 are from cross sections of the upper jaw of an embryo sheep 93 mm. long, which was treated with picrosulphuric acid and stained in borax-carmine.

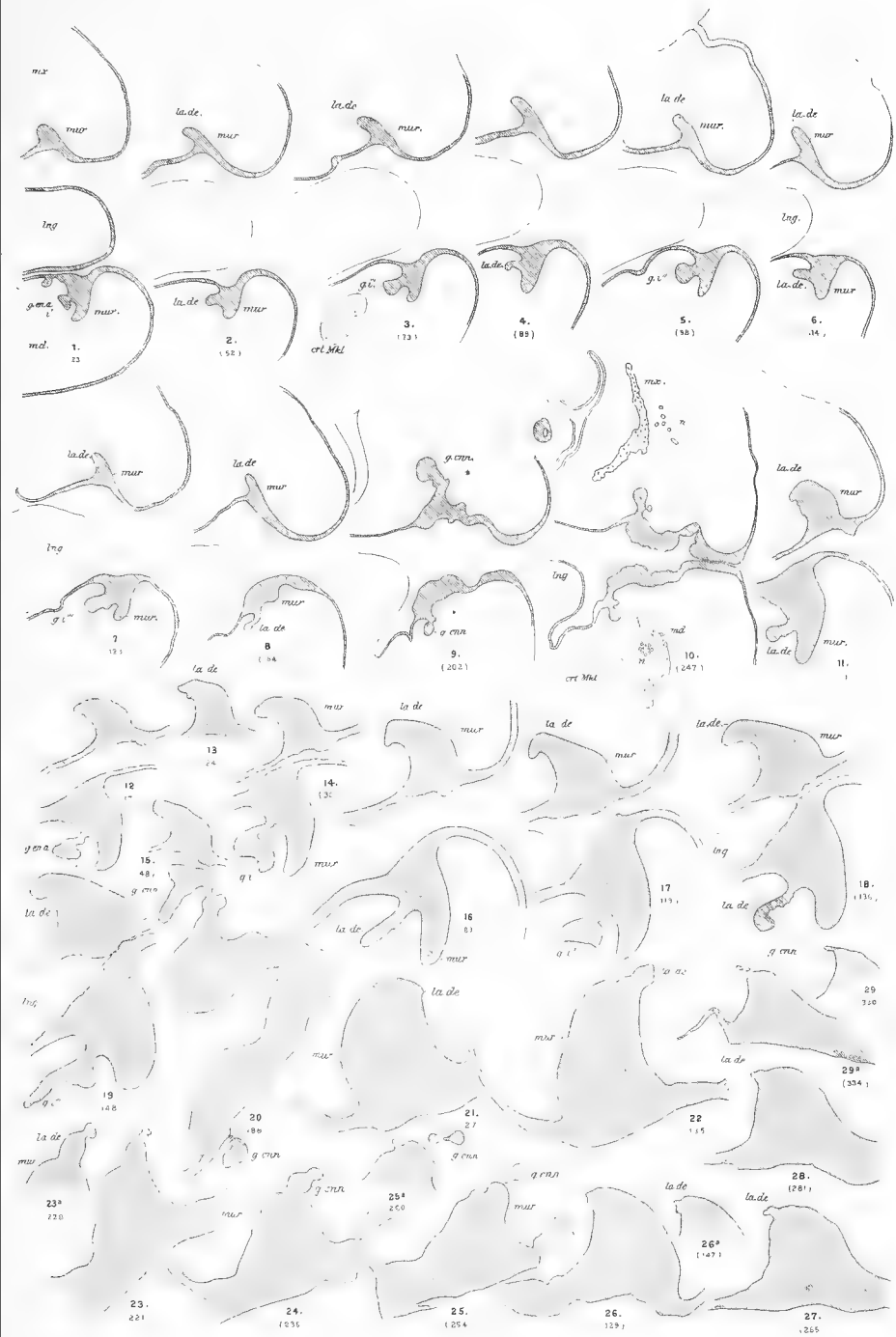
Fig. 33 is a section through the germ of the canine tooth. That portion of the neck of the germ which is nearest the buccal epithelium is resolved into a series of epithelial knots or islands.

Fig. 34 shows the condition of the lamina eight sections behind that shown in Fig. 35, still in the incisor region. The sections were 7.5 μ. thick.

Fig. 35 is the anterior face of a section through the incisor region, showing the condition of the dental lamina in the upper jaw.

Fig. 36. The dental lamina of Fig. 28 as it appears when highly magnified.

Fig. 37. A portion of the section outlined in Fig. 29a. The central cells of the germ have become vacuolated.



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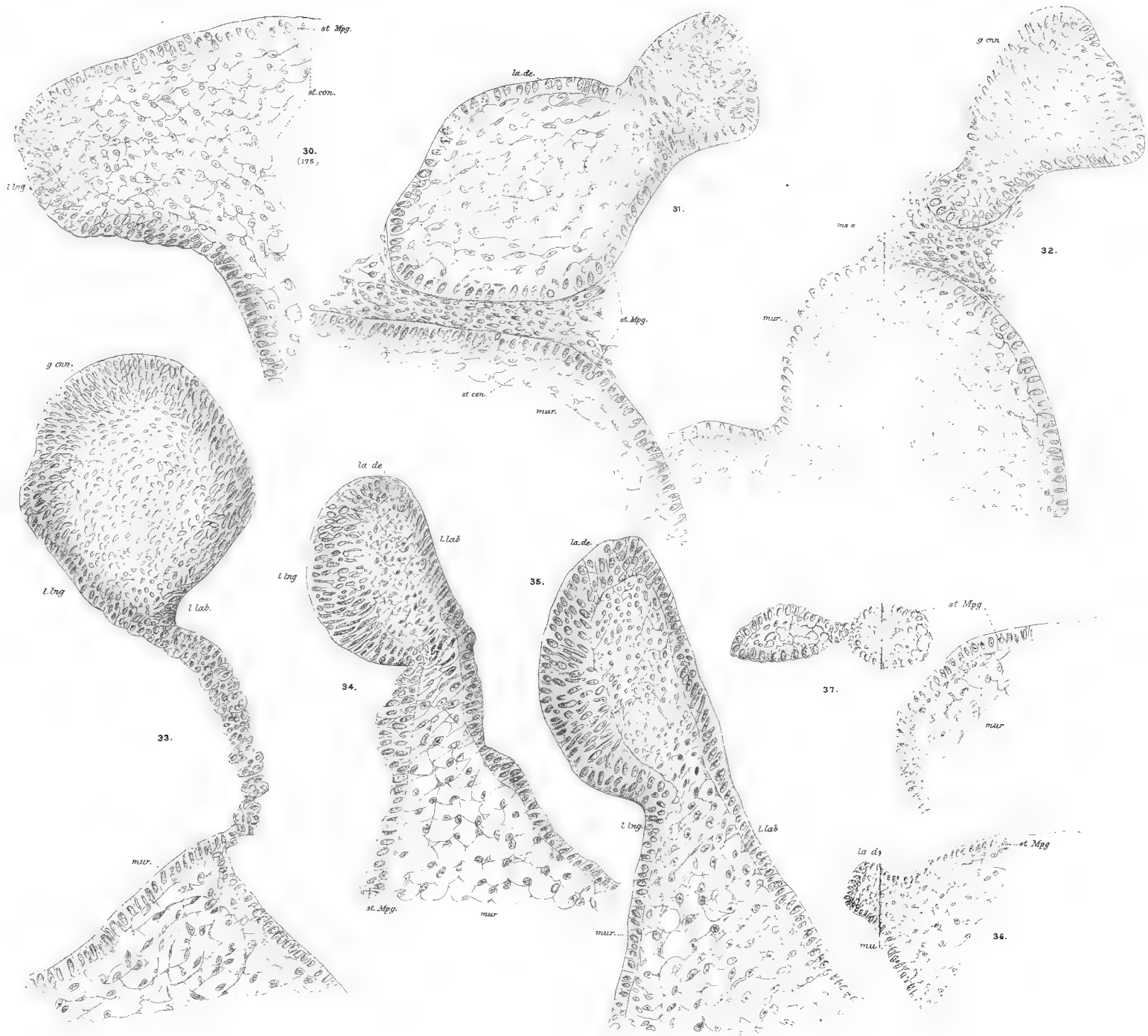

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